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ERROR ANALYSIS IN SCIENTIFIC WRITING: THE CASE OF ESP FOR MECHANICAL ENGINEERING

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Abstract. *The paper presents an error analysis of scientific articles written by non-native speakers of English in the field of mechanical engineering. The main research aim was to determine the most common grammatical errors and provide an explanation for their occurrence. The analysis was mainly qualitative in nature and yielded five major types of errors (related to articles, prepositions, tenses, voices, and subject-verb agreement) and a number of less frequent ones. The majority of these errors arose from interlingual interference, that is, the inadequate transfer of the authors' first language, which was predominantly Serbian, into English. Certain intralingual errors such as those in the use of articles were also identified and described in detail. Hopefully, the results of the analysis might serve as future guidelines for both experienced and young researchers.*

Key words: *Error analysis, Scientific writing, English for specific purposes (ESP), Mechanical engineering, Interlingual and intralingual errors*

1. INTRODUCTION

The importance of the English language in the world of science today cannot be overstated. Driven by the now well-established adage of “publish or perish” [1], global academia relies heavily on English to provide the necessary support in the publication of cutting-edge research across all disciplines. The situation is no different in Serbia, particularly in the field of engineering sciences and technology, where most scientific journals are published exclusively in English. Scientific writing requires a set of highly specific skills and techniques, which become even more difficult to attain as part of a researcher's second language learning process. The basic principles of scientific writing come from the purposes of scientific publications, which are “(1) to *educate*, (2) to *inform*, and (3) to *record*” [2]. To do that, scientific writing must be clear [3], above all else, and its clarity needs to be expressed through its concise and precise nature. According to Booth [4], there is no place for grandiloquence in scientific writing, and scientists and researchers need to convey their ideas effectively, so that readers may

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understand them easily. Yet, the more concise the language, the more skill it requires from a publication's author to make it as effective as desired. The task is even more daunting for non-native speakers of English.

Observed from their viewpoint, scientific writing can be subsumed under the broader term of English for specific purposes (ESP), which, plainly speaking, is the teaching and learning of English for any purpose that can be specified. The present study addresses one such case, where the use of the specific language of mechanical engineering in the production of scientific papers by researchers who are not native speakers of English is examined through the lens of error analysis (EA). The primary goal of this study is to describe and explain the most common errors identified in the proofreading phase of preparing scientific articles for publication in the *Innovative Mechanical Engineering (IME)* journal. The examples presented in the analysis and discussion section should also serve another purpose, and that is to instruct researchers on how to write more clearly and concisely, while keeping the language grammatically correct. Finally, it would be particularly rewarding if young researchers, at the beginning of their professional careers, could benefit from this analysis.

The paper is organized in the following manner. The next section contains the theoretical background of the error analysis (EA) procedure, as well as a review of a selection of its practical applications, upon which this study draws directly. After that, the methods and materials employed in conducting this research are described in detail. The penultimate section combines the presentation of the results with the discussion of the chosen examples. This is done in such a manner as to facilitate future implementation of the most important findings. The paper ends with concluding remarks.

2. ERROR ANALYSIS

As with any other form of communication in a foreign language, scientific writing in English also involves a number of obstacles that non-native researchers must overcome. Similar to other speakers who have acquired English as a second language, these researchers are prone to making various types of errors depending on their level of knowledge. With that in mind, EA can be particularly useful in pinpointing the most common errors and providing guidelines on how they can be corrected and prevented from reoccurring in the future. Put simply, EA studies and scrutinizes errors made by second language learners [1]. According to Ellis and Barkhuizen [2], such errors can appear in both comprehension and production. However, since comprehension errors are much more difficult to detect, EA primarily relates to identifying, describing, and explaining production errors [2]. In laying the groundwork for EA, Corder [3] divided language errors into errors of performance (unsystematic mistakes occurring due to memory lapses, physical states, etc.) and errors of competence (systematic, knowledge-related faults), stating that the latter should be examined more closely as they reveal learners' "transitional competence". To Corder [3], the purpose of such analysis would be threefold: it could benefit language teachers, language researchers, and language learners. Even though EA "ha[s] largely been superseded by studies of interlanguage and second language acquisition" [1], it still remains a highly effective tool for all parties involved in the language learning process.

As will be seen presently in the literature review, writing errors can be divided into various categories. They can be grammatical or logical and conceptual; lexical, morphological, or syntactic; related to specific parts of speech (e.g., verbs, prepositions, articles) or particular writing norms and conventions (e.g., spelling, capitalization, punctuation), and so on. Errors can also be categorized according to their causes, and a number of such classifications have been proposed (among others, Brown [4], Dulay and Burt [5], James [6]). Richards [7] was the first to sort errors into two groups based on this criterion: errors arising from interlanguage interference, on the one hand, and intralingual and developmental errors, on the other. His and Schmidt's [1] most recent classification is presented here for further reference:

1. **interlingual errors** – errors which result from language transfer, i.e., caused by the learner's native language,
2. **intralingual errors** – errors which do not result from language transfer but from faulty or partial learning of the target language, and these can further be divided into:
 - a. **overgeneralizations** caused by extension of target language rules to inappropriate contexts,
 - b. **simplifications** resulting from learners producing simpler linguistic rules,
 - c. **developmental errors** reflecting natural stages of development,
 - d. **communication-based errors** stemming from strategies of communication,
 - e. **induced errors** resulting from the transfer of training,
 - f. **errors of avoidance** caused by failure to use certain target language structures because of their perceived difficulty, or
 - g. **errors of overproduction** where certain structures are used too often.

The present study will provide examples of both interlingual and intralingual errors in scientific writing in the field of mechanical engineering.

There are numerous analyses of various types of second language learners' errors in the literature (for a comprehensive review of previous research see, e.g., Al-Khresheh [9] or Heydari and Bagheri [10]). However, since our focus here is on scientific writing, and, more broadly, academic or scholarly writing in general, particular attention will be given to these specific areas of language use. In analyzing scientific papers published in a journal dedicated to transportation science and technologies, Marina and Snuviškienė [11] detected various types of errors, which they categorized into two main groups: grammatical errors (word form, subject-verb agreement, sentence structure, etc.) and logical and conceptual errors (nonsensical constructions, word-for-word translation, etc.). The authors concluded that the main shortcomings were the lack of clarity, concision, and precision, the absence of awareness when using a foreign language to express reality, and the vague formulation of ideas stemming from the disregard for the relative nature of languages. In a similar study, Nguyen [12] determined that the errors found in the examined corpus of scientific papers could be classified into three main groups: lexical errors (49%), syntactic errors (39%), and morphological errors (12%). Furthermore, the author suggested that another major reason for the occurrence of errors was the disinterestedness and carelessness of researchers when it came to organizing their papers. It was concluded that researchers should improve their general knowledge of English grammar, but also work on strengthening specialized vocabulary. Salehi and Bahrami [13] conducted an error analysis of scientific papers written by Persian master's and

doctoral students and extracted eight types of errors: errors in word usage (which had the highest frequency of 36.2%), articles, prepositions, conjunctions, tenses, errors in word order, active-passive structures, and subject-verb agreement (which had the lowest frequency of 0.7%). The authors concluded that the reasons for these errors could be found in language transfer, i.e., that the errors were predominantly interlingual in nature. Their findings implied that teachers and syllabus designers should pay more attention to word usage and articles, above other concerns.

Discussing error analysis from a more general perspective of academic writing, Amiri and Puteh [14] examined different types of errors made by international postgraduate students in Malaysia. Their mixed methodology approach revealed that sentence structure, articles, punctuation, and capitalization were the four most common language errors made by the participants. The authors concluded that the observed errors were both interlingual and intralingual, where the latter were identified as intralingual proper when it came to the incomplete application of rules or faulty generalizations, or developmental when hypotheses were being made about the target language on the basis of the participants' limited knowledge and experience. Alawi [15] performed an error analysis that focused on establishing the error density index and the error production frequency in the academic writing of Filipino university students. A total of 18 error categories were determined, with the top three being verb usage (20%), punctuation (16%), and capitalization (11%). The error density index was 79% on average, which revealed an insufficient level of writing skills, leading the author to suggest a number of changes in terms of syllabus design, preparation of instructional materials, curriculum review, and teaching strategies. Finally, Fitriani et al. [16] performed error analysis in English academic writing by investigating, among other things, the use of translation tools, such as Google Translate, which was employed by 81.8% of their respondents. The results showed that the most common errors were those related to tenses (38.0%), prepositions (11.7%), articles (11.4%), conjunctions (11.4%), omissions (8.9%), subject-verb agreement (6.3%), and adverbs (2.5%). However, one should bear in mind that translation tools are constantly improving and that the development of chatbots (e.g., ChatGPT, Bing Chat, Bard) will certainly lead to fewer errors occurring, albeit at the expense of authenticity and originality.

3. METHODOLOGY AND MATERIALS

The main research aim of this analysis was to determine what types of grammatical errors occur most commonly in scientific papers written by non-native speakers of English. Since the compiled sample was rather small, and with the principally instructive purpose in mind, the performed analysis was exclusively qualitative in character, focusing primarily on identifying and describing different types of errors, without delving deeper into how frequently each of these arose in the analyzed papers. The examined sample comprised journal articles in various subdisciplines of mechanical engineering, and the scientific language used by their authors would fall under the broader designation of ESP. The articles varied widely in language quality, and this can be ascribed to two different scenarios. The first one includes significant differences in the levels of knowledge of the English language among the authors of these papers, while the other assumes the intervention of translators (or the use of translation tools). Since it was not

possible to determine whether any language professional participated in the production of these papers, the first scenario is taken as the more likely reason for the observed diversity in language quality when it came to both form and style.

The sample comprised 36 papers from Volume 1 of the Innovative Mechanical Engineering (IME) journal, published by the Faculty of Mechanical Engineering, University of Niš. The journal covers a wide range of topics in the field of mechanical engineering, which is reflected in the papers themselves. All of the authors were non-native speakers of English, and these included 96 Serbian, seven Ukrainian, two Greek, and one Romanian author, without counting any of them more than once regardless of the number of papers that they authored or co-authored. Before publication, the analyzed papers were proofread by the author of this study, who serves as the main proofreader in the IME editorial team. It was during this process that the errors analyzed here were first identified and corrected, only to be later subjected to a more detailed examination. In this latter procedure, the initial task was to categorize the errors from the perspective of grammar (e.g., articles, use of tenses, subject-verb agreement), which was then followed by an attempt at determining their cause (interlingual vs. intralingual errors). The following section presents the most important findings of this analysis and discusses possible explanations for the detected errors.

4. ANALYSIS AND DISCUSSION

As mentioned above, the main goal of this error analysis was to determine the most common grammatical errors that appear in scientific papers written by non-native speakers of English, with an emphasis on Serbian researchers. The analysis was mainly qualitative in nature; however, the different types of identified errors are presented below based on the number of papers in which they occurred, starting from the errors in the use of articles, which were found in each of the 36 examined papers. The paper numbers provided in brackets designate the number of the issue and the paper itself. For example, Paper 3-4 means that the error was identified in the fourth paper of the third issue of IME Volume 1.

4.1 Articles

These errors are the only ones that were present in all of the examined papers. Regardless of the fact that, unlike Serbian and Ukrainian, both Greek and Romanian possess articles, these errors can easily be categorized under intralingual errors, given the overwhelming number of Serbian and Ukrainian authors. It is a well-known fact that articles present one of the major obstacles for native Serbian speakers learning English, mainly due to the complete absence of this part of speech in their first language, which makes it a difficult concept to grasp. The majority of these errors are omissive, where no article is used, for example:

- (1) *Motor has 30 magnets on *rotor (Fig. 5), and *hall-effect sensor can detect when *rotor magnet passes near *sensor. (Paper 3-4)

When it comes to the errors of omission, there were few observable patterns in the ways in which the authors left out the necessary articles. This showed that even though they

were well aware of both the definite and the indefinite articles, they were still unable to use them consistently. The only two instances of importance are the omission of the definite article at the beginning of a sentence and in describing the elements of equations:

- (2) ...where ε is *small fluctuation parameter, β is *viscous damping coefficient, $f(t)$ presents *time-dependent stochastic function... (Paper 2-12)

In said cases, it appears that these errors stem from overgeneralization, where the authors tried to apply certain target language rules to inappropriate contexts, here specifically the occasional use of the zero article at the beginning of a title or in lists of items.

The other major subtype of article errors was the error of overproduction, which resulted in the excessive use of this part of speech. In the example below, *ejectors* are mentioned for the first time, at the very beginning of the paper:

- (3) The ejectors are jet pumps in which... (Paper 3-5)

Similar examples can be found throughout the analyzed sample, yet the most numerous errors of overproduction were related to the noun + number (or, much less frequently, noun + letter) combinations, such as “the Table 2”, “the Figure 3”, or “the location I”. Postpositive numerals serve much the same purpose as determiners, in that they mark the noun that precedes them, thus rendering the use of the definite article redundant. The omnipresence of this type of error in the examined papers can probably be ascribed to the authors’ understanding of such combinations as decidedly marked, which would in their eyes require the use of the definite article. However, they failed to perceive that the role of these postpositive modifiers is the same as the role of determiners, such as demonstratives (this, that) or quantifiers (some, many), which also make the definite article superfluous.

4.2 Prepositions

The incorrect use of prepositions is the second most common type of error, found in 32 out of the 36 examined papers. Even though certain errors could perhaps be observed as errors of performance rather than errors of competence (e.g., an occasional use of the preposition *of* in collocation with *increase* in a text where *in* was correctly used in the majority of such instances), one particular error is highly pervasive, and it can be explained as a case of interlingual interference. Namely, it was detected that many authors used *on* instead of *in* when referring to figures or graphs, for example, “as can be seen on Figure 4”. This is a direct result of language transfer because in Serbian the preposition *na*, which generally means *on* in the spatial sense, is used to talk about the content of figures or graphs. A similar error is very often made by native Serbian speakers when talking about languages since the preposition *na* is used to describe someone speaking or something being in a specific language, which results in incorrect phrasing such as *speaking on* English*.

4.3 Use of tenses

This type of error was identified in 27 papers, and it can generally be broken down into two subtypes: basic grammar errors and errors in style conventions of scientific writing. As for the former subtype, these errors mainly included the incorrect use of the present or the past simple tense instead of the present perfect tense (Example 4), or the use of the present continuous tense for general truths or habitual actions (Example 5):

- (4) In the last few decades, it became evident that climate change presents a real threat... (Paper 1-3)
- (5) All living walls are acting as a passive biofilter. (Paper 1-5)

The present perfect tense is commonly the most difficult tense to master when it comes to Serbian speakers, due to the fact that Serbian does not possess an equivalent counterpart. Depending on its function in a sentence, the present perfect tense is translated into Serbian either using the Serbian *prezent*, which is a tense equivalent to both the past simple and the past continuous tense, or with the *perfekat*, which again serves as the counterpart to both the past simple and the past continuous tense. This makes it difficult for Serbian speakers to discern when to use the present perfect tense or, for example, the past simple tense, as in the above case. The explanation for the other illustrated error lies in the same domain since Serbian does not differentiate between habitual and ongoing actions tense-wise.

With regard to style conventions, many guides (e.g., [20–23]) agree that scientific writing should employ no more than three tenses: present simple, past simple, and present perfect. Some of these [20] make room for the future simple tense as well, e.g., in discussing perspectives, yet the general consensus is as follows (paraphrased from the APA¹ style 7th edition [24]):

- **the present simple tense** should be used to discuss the implications of the results and present conclusions, or if research findings still hold true,
- **the past simple tense** should be used for the literature review and when describing past events or results of conducted research, and
- **the present perfect tense** should be used when summarizing previous work without stating any actual dates.

Practically, this means that the present simple tense should mainly be used when framing the content of the paper or making general statements such as in the abstract or the introduction. On the other hand, the past simple tense is preferred when citing other researchers' work in order to establish a theoretical framework, as well as in the methodology and analysis sections of a paper. It should be noted here that there exist certain discrepancies between different styles, such as the preferred use of the present simple instead of the past simple tense in MLA.² However, the above guidelines are generally accepted in engineering sciences and technology. What is most important here is that tense usage must be consistent and accurate and that unnecessary shifts in tenses should be avoided at all times, unlike in the following example:

¹ American Psychological Association

² Modern Language Association

- (6) To understand this, they focused on the effects of changing the robots' speed, smoothness, and synchronization on perceived valence, arousal, and dominance, and find that speed had the strongest correlation to these factors. (Paper 3-4)

The vast majority of errors of this second subtype occurred when the authors used the present simple tense to report other researchers' previous work in their literature reviews.

4.4 Active/passive

The next most common type of error, found in 23 papers, was the incorrect use of the active and passive voice. Even though the active has become the more preferred choice, thanks to its concise and clear nature, on the one hand, and the overuse of the passive voice in an attempt to keep the writing objective, on the other [20], one should not rely merely on the active voice in scientific writing. Sometimes the passive is the better option when an author wants to emphasize the object of the sentence, or when the agent is completely irrelevant. Nevertheless, the examined papers contained a number of examples similar to the one below:

- (7) In the paper [5] energy conservation, mitigation of CO2 emissions, and economics of retrofitting for a honey storage building with a Trombe wall for winter heating application were investigated. (Paper 1-5)

This is a common error that occurs when the actual object of the action, which plays the role of the subject in the passive sentence, is too long and the verb has to come at the very end. Such issues are most often resolved by turning the noun at the beginning of the sentence into the subject: "The paper investigated..." Other errors in the use of the two voices included the incorrect application of the active when the passive voice was needed:

- (8) An even more pessimistic image presents by the data series... (Paper 1-9),

the mixing of the two voices:

- (9) It can be find in the literature... (Paper 1-2),

or the excessive use of the passive, such as in the following case:

- (10) It should be borne in mind that the reduction of the flow... (Paper 1-10),

which could have sounded much less clunky if the active voice had been employed: "One should bear in mind..." Again, it could be argued that these errors stem from language transfer, since the passive has a more concise and clearer form in Serbian, mainly due to the position of the verb that does not necessarily have to follow the subject of the passive sentence.

4.5 Subject-verb agreement

The subject-verb agreement in English is primarily related to grammatical number and less often person. The errors in subject-verb agreement appeared in 13 papers and most of them could be described as errors of performance since they did not occur consistently in any of the papers. Some examples of these are:

- (11) When σ rise, the power density curve becomes flat. (Paper 2-12)
- (12) ...robotics engineers who deal with such types of mini 4-leg robots has to solve the problem. (Paper 3-8)

However, one subtype of these errors might perhaps be understood as errors of competence, albeit merely tentatively since there were only a few of these detected in the examined papers:

- (13) The reason are the advantages that DT technology brings... (Paper 3-11)

The subject-verb agreement in English prescribes that the verb must always match the subject of the sentence and not the predicate noun, as is the case in Example 13. Due to the scarcity of these errors, it can only be postulated that they are also the consequence of interlingual interference, since predicate nouns can, indeed, change the grammatical number of verbs in Serbian.

4.6 Other important errors

This section contains the types of errors that were identified in fewer than 10 papers during the analysis. Nevertheless, they are still of much importance for this study. As with the previous types, these errors will be ordered according to the number of papers in which they occurred.

4.6.1 Capitalization and spelling (8 papers)

These errors mainly included the unnecessary use of capital letters, such as:

- (14) Resistance spot welding or Resistance element welding (Paper 1-11)
- (15) A similar problem of mini specialized robotic platforms also exists in the Engineering discipline of Mechatronics. (Paper 3-8)
- (16) ...predictive maintenance also requires a strategy that would consider the Railway system as a whole. (Paper 3-11)

All of the above examples can be described as overgeneralizations of certain capitalization rules in English. As for the spelling errors, the only noteworthy issue is the occasional mixing of the British and American variants in instances such as modelling/modeling or behaviour/behavior. Still, the majority of papers were fully consistent when it came to the use of the preferred style of spelling.

4.6.2 Which/whose (8 papers)

Here, *which* was quite often used instead of the possessive pronoun *whose*. This developmental error is illustrated by the following examples:

- (17)...unlike many other MCDM methods, which application requires specialized software packages... (Paper 2-5)
- (18)A cantilever beam (Fig. 5) is an important element in mechanical engineering, which design is to be handled with utmost care. (Paper 2-9)

4.6.3 Noun-pronoun agreement (6 papers)

There were also several errors related to the incorrect agreement between a noun and its (possessive) pronoun, as can be seen from the examples below:

- (19)Mean U-values for both roofs and its standard deviations... (Paper 1-6)
- (20)Natural clays are abundant throughout the world, formed as a result of the gradual chemical weathering of rocks on the earth's surface. It is a natural mixture of clay minerals and some other materials. (Paper 2-10)

4.6.4 Adjective/adverb (4 papers)

The final presented type is another developmental error, in which adjectives were used instead of adverbs to describe the verb more closely:

- (21)...the decision-making rule generation and its application to the ranking process was performed faster, more comfortable and reliable. (Paper 2-5)

Other grammatical errors occurred only randomly and are therefore not included in the present analysis.

5. CONCLUSIONS

Overall, the quality of language in the examined papers was on a tolerable level given that the authors were non-native speakers of English. As mentioned in the methodology section, there were significant variations in the levels of knowledge among the authors, and certain papers accounted for the majority of identified errors. Still, bearing in mind the importance of scientific writing for their careers, it is highly recommended that the authors continue to improve their knowledge, particularly regarding the specific skills and techniques required by this type of communication. Hopefully, the error analysis presented in this paper can serve as a guide that could help researchers increase their competence in English, primarily by providing basic instructions on the covered types of errors.

The main stumbling blocks in the examined sample were articles, prepositions, tenses, voices, and subject-verb agreement, and these are the areas that the authors of the papers should pay the most attention to. Apart from a small number of truly intralingual errors, such as the ones involving articles, it can be concluded that the majority of issues arose

from interlingual interference, and the authors should be aware of that as well. One's first language is not always the best place to look for solutions to certain problems, and simply trying to translate something from English into Serbian, for example, might not only yield an inadequate equivalent, but can easily lead one astray.

This analysis focused on grammatical errors and their qualitative aspects. Even though the identified types of errors were ordered according to the number of the examined papers in which they were found, that did not provide a sufficiently detailed insight into their frequency of occurrence. This limitation could be overcome by adopting a quantitative approach, in which each particular error would be separately marked for further statistical analysis. Such an approach would establish a much clearer picture of the actual number of each error and help in formulating more precise instructions. In addition to this, future research could also include larger samples and more emphasis on stylistic conventions or idiomatic expressions, among other things. English has been a dominant force in the world of science for quite some time, and it does not seem that the situation will change soon. The more effectively researchers harness its power, the more successful they will be in their careers.

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